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FACTORS INFLUENCING PREFERENCE AND MEMORY FOR AUDITORY RHYTHM

BY

THOMAS WILLARD HARRELL

A dissertation submitted to the Board of University Studies of The Johns Hopkins University in conformity with the requirements for the Degree of Doctor of Philosophy.

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VITA

Thomas Willard Harrell was born in Troup County, Georgia, on September 8, 1911. He received all of his elementary and high school education in West Point, Georgia. In 1928 he entered the University of Georgia and received the A. B. degree in 1932, and the M. S. degree in 1933. During the years, 1931-1933, he was an assistant in the Psychology Department, conducting beginning laboratory sections and doing clinical work. He has been a graduate student and student assistant in The Johns Hopkins University Psychology Department from 1933 to 1936. He pursued research upon the selection of cotton mill workers for the Callaway Mills in the summer of 1935.

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FACTORS INFLUENCING PREFERENCE AND MEMORY FOR AUDITORY RHYTHM*[1]

The Johns Hopkins University

THOMAS WILLARD HARRELL

HISTORY

The study of rhythm, that is, accenting recurring impressions either in intensity, duration, or pitch has been of interest from a literary (Stetson, 30), musical (Seashore, 27), and physiological (Jasper and Andrews, 14) standpoint as well as psychological.

Meumann (20) divided theories of rhythm into five classes: (*a*) developmental historical hypotheses; (*b*) teleological theories; (*c*) pure physiological explanations; (*d*) psychophysiological theories; (*e*) pure aesthetic theories. Swindle (32) considered that his experiments proved that rhythmic forms are acquired rather than instinctive.

The experimental study of rhythm is related to reaction time (Blake, 2) and synchronizing reactions (Leatherman, 16) as well as to the time sense. Woodrow (37) has reviewed the literature and experimented upon the accuracy of reproducing temporal intervals. He reports that Vierordt, Mehner, and Glass found that the indifference interval, i.e., the interval which was overestimated as often as it was underestimated, varied from 0.75 to 5.0 seconds with the investigator and with the experimental conditions. The indifference interval was 0.6 second in Woodrow's experiment.

Ruckmick (24) has compiled the most complete bibliography on rhythm in four articles which include 741 titles.

Earlier experimenters considered "the attention wave" (Arps and Klemm, 1) to be a sufficient explanation of rhythmic grouping. As in other psychological controversies, the periphery soon became pitted against the central nervous system; the periphery in this case was represented by a motor theory of rhythm (Miner, 23; Stetson, 31;

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Ruckmick, 25). Dunlap (9) found the attention wave theory inadequate since it does not account for those frequent cases of rhythmic groupings in which other members of the group than the first are accented. Dunlap (10) also questioned the value of kinesthesis as an explanatory principle but he admitted its place at the descriptive level and concluded that "the rhythm group is essentially connected with the specious present."

It was thought at one time that rhythmic perception was possible only for auditory sensations and that there was a special rhythm sense organ connected with the auditory mechanism. Later the perception of rhythm with visual stimulation (Miner, 23; Koffka, 15), muscular sensations (Stetson, 31) and electrical stimulation (Woodrow, 35) was asserted.

Many devices have been used as apparatus for producing recurring auditory stimuli. These include interrupting the vibrations of a tuning fork resonator with a sectored disc (Bolton, 4), metronome (Wallin, 33), weighted spring vibrator (Dunlap, 11), hammer (Meumann, 19), the Schumann chronograph (Dunlap, 8), pendulum (Arps and Klemm, 1), water dripping device (Dunlap, 7), the break of an induction circuit (Woodrow, 35), victrola (Seashore, 29). The principle apparatus difficulty has been that of moving parts.

The first experiment with the word "rhythm" in the title was performed by Hall and Jastrow (12) in 1886 upon the accuracy of counting clicks. Bolton (3) also investigated the discrimination of clicks. He found that 10 was the largest group that his subjects accurately discriminated when the rate was 133 per second.

Meumann (18) was a pioneer who gathered the pre-experimental opinions about rhythm and outlined some problems. Meumann (19) reported that subjects judged a rate to be faster than a similar rate at a lower intensity.

The article of Bolton (4) reports experiments which bear a close connection to our original problem, i.e., what is the preferred rate for a group of uniform clicks? The length of the group decreased from 1.581 seconds to 1.160 when subjects chose their preferred rate as the size of the group increased from two to eight. Wallin (33, 34) found that the average preferred tempo of metronome clicks was 0.519 second. Grouping was not suggested in this case. Several experimenters (Dresslar, 6; Brown, 5; Seashore, 26; Miles,

22) have investigated preference for rate of movement. The unwarranted conclusion has been drawn from Seashore's investigation (26) that there is a causal relation between pulse rate and breathing on the one hand and preferred tapping rate on the other. Miles (22) had subjects tap on a key and found wide individual differences and considerable intra-individual differences. The latter were less than the individual differences.

Heinlein (13) had observers try to tap synchronously with the steps of marching children while music was played. The taps were not synchronized with the steps but were strongly influenced by the music tempo.

MacDougall (17) found that a loud sound introduced into a uniform series of six beats caused a considerable underestimation of the interval following the loud sound, while it less often and less considerably lengthened the preceding interval. Woodrow has made the most thorough investigation of objective factors which influence the perception of grouping. He found (35) that intensity has a group-beginning effect; duration a group-ending effect; and (36) that pitch has neither a group-ending nor a group-beginning effect.

Apparatus

An apparatus was designed which would give identical sounds at regular intervals to study whether there is a preference for a particular rate of auditory stimulation.[2] It was possible to make continuous changes in rate by moving a rheostat arm. The rate was that at which a condenser discharged through a neon bulb. The condenser discharge principle had been used before, in timing circuits, e.g., to actuate relays in tachistoscopic exposure (21), and as a part of a chronoscope, but it has never been utilized before for a "rhythm machine." Objection may be raised to the term "rhythm machine" inasmuch as there is no accent by intensity, or difference in time between any two pair of clicks at any one setting of the oscillator. Not attempt will be made here to decide whether rhythm must involve either, or both of these factors.

The negative side of the 220-volt direct current line was con-

[2]Dr. F. W. Hamburger of the Electrical Engineering Department and Dr. R. M. Dorcus of the Psychology Department devised the condenser discharge oscillator.

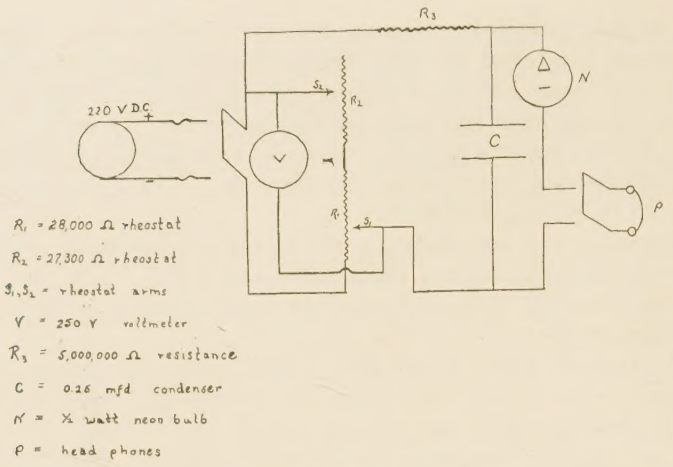

FIGURE 1
DIAGRAM OF CONDENSER-DISCHARGE OSCILLATOR CIRCUIT

nected to one side of *R*1 (Figure 1). The positive side of the line was connected in parallel to the sliding arm, *s*2 of *R*2, and to one side of the fixed resistance, *R*3. *R*1 was in series with *R*2. A voltmeter, *V*, was connected across the rheostate arms, *s*1, and *s*2. Parallel connections were made from *s*1 to one side of the condenser, *C*, and to the phones, *P*. The other side of the condenser was connected in parallel to *R*3 and to the neon bulb, *N*. The neon bulb was connected in series with the phones.

The resistance of the neon bulb, *N*, caused the current to build up in the condenser until it reached a sufficient level to ignite the gas. The ignition of the bulb produces a click in the phones and discharges the current from the condenser. This process of current building up and discharging through the phones goes on over and over. The rate of discharge depends upon the voltage across the two rheostat arms *s*1 and *s*2, if other factors are constant. The rheostates, *R*1, and *R*2, act as a voltage divider. The neon bulb used ignited on a little over 60 volts. The total range of rates could be obtained by the appropriate setting of *s*1 and *s*2. It was possible to obtain a range of rates from one click in two seconds to 10 clicks per second. The extreme limits varied slightly on different series of experiments on account of several changes in the apparatus

which had to be made. A number of condensers in parallel was later supplanted by one condenser. One neon bulb burned out and had to be replaced. A different set of headphones had to be substituted because a wire came off the magnets in the original set, and the attempt to solder the wire was ineffectual. In each case of change new calibration tables for rate against voltage were made.

The three factors affecting the rate and range, i.e., size of condenser, resistance of *R*3, wattage of the neon bulb, were kept constant. The bulb was covered with a tin shield since it ignited at a lower voltage with more light upon it.

The rate of clicks is a straight line function of voltage (Figure 2).

FIGURE 2

CHANGES IN RATE OF CLICKS WITH VOLTAGE

The voltage is shown along the abscissa. The rate of clicks per second is shown on the ordinate.

Calibration of rate against voltage was made with the Cambridge string galvanometer. A practice string was used with no protective resistance. The subjects' leads of the galvanometer were connected

in series with the phones of the oscillator, and photographs were made of the string oscillations. The resistance of the string was not enough to alter appreciably the rate of discharge. Many calibrations were made of the slower rates by counting the clicks for a certain time, as measured by a stop clock. The rate was approximately constant for a given voltage. It is true that variations of several hundredths of a click per second were found on different days, but this variation might have been due to differences in reading the voltmeter. For any given rate it is not possible to say what the variation in time between any pair of clicks was. According to the galvanometer pictures the click rate is as uniform as the fifth-second time line which was furnished by a Jacquet Chronometer.

Changes in line voltage of one to two volts occurred occasionally slowing the rate. These changes, which could be detected from the voltmeter, were compensated for by varying the voltage divider.

Procedure

The problem in the first series of experiments was to determine preferences for rates of uniform equally spaced clicks when there was no suggestion of grouping. In another series of experiments preferences were asked for rates when the clicks were subjectively grouped by twos, threes, fours, fives, and sixes.

Bolton (4) had touched upon this problem in having subjects find the optimal rates for various groupings, and Wallin (34) determined the preference of subjects for rates of metronome clicks. The repetition of some phases of this earlier work seemed important since the present apparatus permitted practically continuous rate variations; and since the changes could be easily and quickly made by moving a rheostat arm, it was feasible to have the subject "find" his preferred rate.

The reactor was asked to put on the headphones and listen to the clicks while the experimenter slowly moved the rheostat arm from the slowest rate to the fastest and back to the slowest. These typewritten instructions were presented then to the reactor:

> Move this arm to the rate to which you prefer to listen. You may move the arm as much as you like, and take as long as you wish. If you do not like to listen to any of the rates, choose the one which you dislike least.

The experimenter recorded the voltmeter reading for the reactor's

preference; moved the rheostat arm to the setting which gave the fastest rate; and presented the following instructions:

> Now choose the rate you prefer to listen to.

After recording this choice and without moving *S*1, these typewritten directions were placed before the subject:

> Group the clicks by twos and choose the rate to which you prefer to listen.

Some reactors inquired how they should do this. The experimenter replied that it might be necessary to count the clicks, "one, two, one, two." The experimenter tried not to accent this counting in time or in intensity.

The following preferences for rates were obtained by using the above procedure:

> Group the clicks by "threes" and choose the rate to which you prefer to listen.
> The same for "fours."
> The same for "fives."
> The same for "sixes."
> Without any grouping, please choose the rate to which you prefer to listen.

After the amount of musical training and the frequency with which the reactor danced were ascertained, the following questions were asked:

> 1. Can you give any reasons for your choices, non-grouped? Grouped?
> 2. Before the suggestion of grouping was made, did you group the clicks? If so, how?
> 3. Did you have any trouble in not grouping the clicks, when you were asked not to?
> 4. Did you have trouble making any of the groupings?
> 5. Which grouping was the most natural?
> 6. Which grouping was the most difficult?
> 7. How did you group the clicks? By accent? By time?

Preferences were obtained on a later day with no suggestion of grouping followed by grouped preferences in the order, sixes, fives, fours, threes, two, and finally with no grouping.

Seventeen men and ten women were put through this procedure. Seventeen were graduate students in psychology; the others were

undergraduates. The subjects are designated by their initials. The majority of subjects who were used in this "preference" group of experiments were also used in later experiments.

Preference for Rates

The results are negative in that they do not show any uniform preference among individuals for a rate. The monotony of the stimuli may account for these results and it might be contended that with more pleasing stimuli the results would be drastically changed.

The average preferred rate was 5.08 clicks per second, with a

TABLE 1

Preference for Rates in Clicks per Second with No Suggestion of Grouping

	First day Trial					Second day Trial				Av. 5	
	1	2	3	Av.	MV	1	2	Av.	MV	Trials	MV
CEW	1.0	0.9	1.4	1.1	0.2	5.2	2.3	3.8	1.5	2.2	1.3
MB	1.5	1.7	1.9	1.7	0.1	1.3	2.3	1.8	0.5	1.7	0.3
San	1.6	1.5	2.0	1.7	0.2	1.3	1.8	1.6	0.3	1.6	0.2
VCJ	1.7	0.9	0.9	1.2	0.4	0.9	0.9	0.9	0.0	1.1	0.3
RB	1.9	1.9	2.1	2.0	0.1	1.3	1.1	1.2	0.1	1.7	0.4
Gra	1.9	1.9	2.1	2.0	0.1	2.7	4.0	3.4	0.7	2.5	0.7
HP	2.0	2.3	2.1	2.1	0.1	1.8	1.4	1.6	0.2	1.9	0.3
Mal	2.5	2.2	3.1	2.6	0.3	2.8	3.8	3.3	0.5	2.9	0.5
ETM	2.8	3.8	4.2	3.6	0.5	5.2	5.1	5.2	0.1	4.2	0.8
RBB	3.1	4.4	3.7	3.7	0.4	5.1	4.1	4.6	0.5	4.1	0.6
AKB	3.2	3.0	4.3	3.5	0.5	2.5	1.7	2.1	0.4	2.9	0.7
SL	3.3	3.4	5.1	3.9	0.8	7.9	5.0	6.5	1.5	4.9	1.3
TWZ	4.4	3.6	7.0	5.0	1.3	4.7	6.8	5.8	1.1	5.3	1.3
CDL	4.9	5.4	4.9	5.1	0.2	4.4	4.7	4.6	0.2	4.9	0.2
DH	5.0	3.7	5.0	4.6	0.6	4.8	5.0	4.9	0.1	4.7	0.4
WR	5.0	4.0	5.0	4.7	0.4	5.7	5.1	5.4	0.3	5.0	0.4
Abr	5.7	6.0	8.2	6.6	1.0	6.1	7.5	6.8	0.7	6.7	0.9
PG	6.6	6.7	5.7	6.3	0.4	6.5	5.0	5.8	0.8	6.1	0.6
FJ	6.8	7.1	6.9	6.9	0.1	6.9	5.9	6.4	0.5	6.7	0.3
VK	7.5	5.2	8.0	6.9	1.1	7.6	7.4	7.5	0.1	7.1	0.7
Cla	8.4	8.4	7.4	8.1	0.4	10.4	10.9	10.7	0.3	9.1	1.2
Ekl	8.5	6.2	5.0	6.6	1.3	8.6	7.5	8.1	0.6	7.2	1.2
Bal	8.5	8.3	7.6	8.1	0.4	8.7	7.9	8.3	0.4	8.2	0.4
FMc	8.4	12.9	8.7	10.0	1.9	8.6	8.9	8.8	0.2	9.5	1.4
Cap	8.9	9.3	0.5	6.2	3.8	0.9	0.5	0.7	0.2	4.0	4.1
MR	9.3	9.2	9.4	9.3	0.1	9.0	9.2	9.1	0.1	9.2	0.1
MC	12.0	11.7	13.3	12.3	0.6	8.5	8.5	8.5	0.0	10.8	1.8
Av.	5.05	5.02	5.02	5.03	0.6	5.17	4.98	5.07	0.44	5.08	0.83

Mean variation from the general average of all choices, 2.49.

mean variation of 2.49 clicks per second (Table 1), when grouping the clicks was not suggested. This average was for 27 subjects who each made five choices. Two choices were made on one day, and three on another. The range of choices was 0.5 to 13.3 clicks per second and covered the possible range of rates.

The average of all subjects for each of the five trials taken separately varied only between 5.0 and 5.2 clicks per second and showed no significant trend from one trial to the next. There was no evidence of any effect from the starting rate upon the rate chosen, i.e., the averages were similar when the subjects heard a slow rate before they made their choice to those when a fast rate was heard initially.

Almost all of the subjects showed fairly consistent preferences from one trial to another and from day to day. This consistency is shown by the high rank difference correlations between trials. The first three trials were made on the first day, the fourth and fifth trials were made on the second day. The correlation between ranks on trial one and trial two was +0.96; between ranks on trials two and three, +0.71; between three and four, +0.84; between four and five, +0.92; between the average of the three trials on the first day and the average of the two trials on the second day, +0.95. Correlations of a similar kind were computed between the ranks of rate preferences when the clicks were subjectively grouped. The correlations are for similar trials on different days; groups of two, +0.59; groups of three, +0.84; groups of four, +0.76; groups of five, +0.72; groups of six, +0.76. Although consistency of preference was not sought by the instructions, or in any way by the experimenter, it is possible that the subjects tried to be consistent for the sake of consistency, and not because they definitely preferred the rate each time.

Later experiments will throw some light upon the question of how definite the preference is. In one set of experiments the subject reproduced his preferred rate (he was not told that the standard was his preference) and rates faster and slower than the preferred rate, to find whether more accuracy would be shown for the preferred rate. Another indirect indication of the definiteness of the preferred rate is found in comparing variations in preferred rates with variations in rates chosen on different days for some specific

activity. The activities prescribed in the instructions were singing a song, hearing a piece of music, and waltzing.

The average mean variation of each subject's five choices was 0.83 clicks per second. Similarly, the average *MV* for the three trials on the first day was 0.60 clicks per second, and for the two trials on the second day was 0.44 clicks per second. The larger *MV* for the general average than for the *MV*'s of the separate days does not give a representative picture inasmuch as only 8 of the 27 cases showed this trend.

TABLE 2

PREFERENCE FOR RATES IN CLICKS PER SECOND WITH THE CLICKS SUBJECTIVELY GROUPED

	Groupings									
	Twos		Threes		Fours		Fives		Sixes	
	Day		Day		Day		Day		Day	
	1	2	1	2	1	2	1	2	1	2
CEW	1.8	1.8	2.7	2.6	2.8	3.0	3.0	3.5	3.8	4.4
MB	1.7	3.4	3.2	4.2	3.8	5.6	4.7	6.8	5.2	7.5
San	4.0	2.9	5.8	4.3	6.4	6.5	7.0	7.4	8.3	8.9
VCJ	1.5	1.3	1.6	2.0	1.8	1.8	2.0	2.1	2.2	2.3
RB	3.3	1.7	3.9	1.7	2.5	1.8	3.1	2.2	2.5	1.8
Gra	2.4	2.3	3.2	2.6	3.6	3.1	4.0	3.5	3.8	3.8
HP	1.6	1.8	2.5	2.0	2.5	2.1	2.8	2.3	3.2	2.7
Mal	2.7	2.8	3.4	3.6	4.2	4.2	5.0	4.7	6.2	6.6
ETM	3.5	3.8	4.6	5.4	4.6	5.6	4.0	5.4	4.8	6.4
RBB	2.9	3.4	2.9	3.8	3.8	3.8	4.0	3.7	3.3	3.9
AKB	3.0	1.3	2.1	3.6	2.0	2.5	2.4	3.0	2.5	4.3
SL	6.0	3.5	4.0	4.6	5.0	4.4	4.4	4.9	5.0	5.0
TWZ	7.1	8.5	10.1	9.4	11.9	7.6	8.9	7.0	7.9	6.0
CDL	5.4	3.4	4.9	4.5	5.5	4.4	5.4	4.3	5.0	4.6
DH	8.2	5.0	5.7	6.9	5.0	7.7	5.2	6.9	5.4	6.8
WR	4.3	5.2	4.3	5.2	4.8	5.4	4.1	4.7	4.9	4.9
Abr	5.8	7.3	7.6	7.0	8.5	6.7	8.3	6.4	8.3	6.4
PG	6.0	6.1	5.2	5.6	5.6	5.3	4.4	5.7	4.5	5.1
FJ	1.7	2.0	2.7	2.5	3.6	3.4	5.1	4.7	5.9	6.0
VK	5.0	2.4	5.4	5.6	5.9	5.0	5.9	4.3	5.9	7.3
Cla	3.0	6.9	5.2	7.2	5.9	8.3	4.0	7.7	4.7	6.6
Ekl	5.2	6.0	4.0	6.7	5.5	7.6	6.3	8.8	6.0	9.4
Bal	2.5	6.2	2.5	3.1	7.8	3.4	3.9	4.5	5.0	5.4
FMc	2.7	10.2	5.7	4.7	3.9	4.4	4.6	4.8	*	4.2
Cap	10.2	6.0	4.7	3.6	4.8	4.4	4.9	4.6	5.2	6.6
MR	7.6	8.7	7.0	7.5	6.7	6.3	6.3	5.0	6.0	4.0
MC	5.6	9.0	6.3	10.3	7.6	9.6	8.6	8.9	9.1	8.6
Av.	4.2	4.5	4.5	4.8	5.0	5.0	4.9	5.1	5.2	5.5
Av.	4.4		4.7		5.5		5.0		5.3	
MV	2.10		1.61		1.87		1.40		1.43	

*The subject reported that she could not group the clicks by sixes although she made a preference with this grouping on the second day.

TABLE 3

PREFERENCE FOR RATES IN SECONDS PER GROUP WITH CLICKS SUBJECTIVELY GROUPED

	First day Groupings					Second day Groupings				
	2	3	4	5	6	2	3	4	5	6
CEW	1.04	1.07	1.43	1.68	1.58	1.11	1.15	1.33	1.43	1.36
MB	1.18	0.94	1.05	1.06	1.15	0.59	0.71	0.71	0.74	0.80
San	0.50	0.52	0.63	0.71	0.72	0.69	0.70	0.62	0.69	0.67
VCJ	1.33	1.87	2.22	2.50	2.73	1.54	1.50	2.21	2.38	2.60
RB	0.61	0.77	1.60	1.61	2.40	1.18	1.76	2.21	2.27	3.34
Gra	0.83	0.94	0.90	0.80	1.58	0.87	1.15	1.29	1.43	1.58
HP	1.25	1.20	1.60	1.77	1.87	1.11	1.50	1.90	2.17	2.22
Mal	0.74	0.87	0.96	1.00	0.97	0.71	0.83	0.95	0.93	0.91
ETM	0.57	0.66	0.87	1.25	1.25	0.53	0.58	0.71	0.93	0.94
RBB	0.69	1.03	1.05	1.25	1.82	0.59	0.79	1.05	1.35	1.54
AKB	0.67	1.43	2.00	2.08	2.40	1.54	0.83	1.60	1.66	1.39
SL	0.33	0.75	0.80	1.14	1.20	0.57	0.65	0.91	1.02	1.20
TWZ	0.28	0.30	0.33	0.56	0.76	0.24	0.32	0.53	0.71	1.00
CDL	0.37	0.61	0.72	0.93	1.20	0.59	0.67	0.91	1.16	1.30
DH	0.24	0.53	0.80	0.96	1.13	0.40	0.43	0.52	0.72	0.88
WR	0.47	0.70	0.83	1.22	1.22	0.39	0.58	0.74	1.06	1.22
Abr	0.35	0.40	0.47	0.60	0.72	0.27	0.43	0.60	0.78	0.94
PG	0.33	0.58	0.71	1.14	1.33	0.33	0.54	0.76	0.88	1.18
FJ	1.18	1.11	1.11	0.98	1.02	1.00	1.20	1.18	1.06	1.00
VK	0.40	0.56	0.68	0.85	1.02*	0.83	0.54	0.80	1.16	0.82
Cla	0.67	0.58	0.68	1.25	1.28	0.29	0.42	0.48	0.65	0.91
Ekl	0.39	0.75	0.73	0.79	1.00	0.33	0.45	0.53	0.57	0.64
Bal	0.80	1.20	0.51	1.28	1.20	0.32	0.97	1.18	1.11	1.11
FMc	0.74	0.53	1.03	1.09	*	0.20	0.64	0.91	1.04	1.43
Cap	0.20	0.64	0.83	1.02	1.15	0.33	0.83	0.91	1.09	0.91
MR	0.26	0.43	0.60	0.79	1.00	0.23	0.40	0.64	1.00	1.50
MC	0.36	0.48	0.53	0.58	0.66	0.22	0.29	0.42	0.56	0.69
Av.	0.62	0.80	0.95	1.14	1.33	0.63	0.77	0.99	1.13	1.26

	Groupings				
	2	3	4	5	6
Av.	0.63	0.78	0.97	1.14	1.29

*The subject reported that she could not group the clicks by sixes although she made a preference with this grouping on the second day.

The outstanding fact about the preferences when the clicks were subjectively grouped was the consistent increase in time per group with increase in the number in the group (Tables 2 and 3; Figures 3 and 4). Fifteen of the 27 subjects chose rates which gave successively longer (time) groups with increase in size (number) of the group on the first day; 17 did this on the second day. There was not a case of a successive decrease in the time per group with increasing the group number. It is interesting to note that when

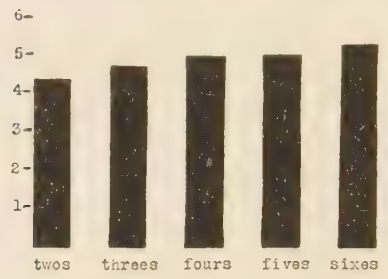

FIGURE 3

PREFERRED RATES, IN CLICKS PER SECOND, WHEN CLICKS WERE SUBJECTIVELY GROUPED

Averages for 27 subjects.

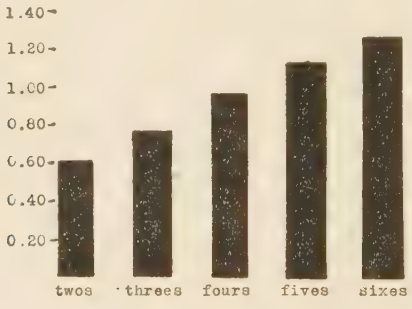

FIGURE 4

TIME PER GROUP, IN SECONDS, WHEN CLICKS WERE SUBJECTIVELY GROUPED

Averages for 27 subjects.

the subjects grouped first by sixes, then fives . . . twos, the time ratios were the same as when the preferences were made in the reverse order, twos, threes . . . sixes. It might be contended that our results simply show that it takes a person longer to count to six than to two. This simple explanation seems inadequate because there is a fairly uniform tendency to increase the rate with the size of the group.

The average rates (in clicks per second) chosen when the clicks were subjectively grouped were twos, 4.40, *MV* 2.10; threes, 4.68, *MV* 1.61; fours, 4.98, *MV* 1.87; fives, 4.98, *MV* 1.40; sixes, 5.26, *MV* 1.43. The average rates were a little faster on the second

day for all groupings except fours when the order of trials was sixes . . . twos.

The average time in seconds per preferred group was twos, 0.625; threes, 0.785; fours, 0.97; fives, 1.135; sixes, 1.29.

The answers to the questions indicate that over half of the reactors preferred grouping by fours. Some would not choose between two or more groupings. Twos, threes, fives, and sixes were mentioned as a preferred grouping by at least one reactor.

A majority of the reactors accented the first click of a group. One person accented the second in grouping by threes. One reactor accented the third click but less strongly than the first click, in grouping by fours. Another accented the fourth as well as the first click in the four groupings. One reactor accented the second and last clicks in each group. Two others accented the fourth as well as the first click in sixes, or as he explained, he might have been grouping by threes. One accented the third in fives. One accented the second in fours.

Fives was the hardest grouping to make in two-thirds of the cases, followed in difficulty by sixes, twos, and threes. Only two reactors thought that their grouping was on a time basis. The remainder judged it to be a matter of intensity.

After grouping the clicks subjectively half of the reactors tended to continue grouping even when asked for a preference with no grouping. Very few of the reactors had difficulty in making most of the groupings.

No definite pure esthetic preferences for rates were found. The answers as to why the rate was chosen were in general of two kinds. The rate was chosen on the basis of some association such as the sound of a clock, a motor, swimming movement rate, dancing-tempo. In some instances there was no definite preference but the rate was arrived at by elimination. Several cases who said that their choice was the fastest rate that they could count belong in this latter class. Although this reason was given by several reactors, the choices of those reactors showed wide variations. There were a few choices which might have been made so that the reactor could "get it over with." Several reactors expressed themselves as being bored with the experiment.

No significant relation has been found between musical training or frequency of dancing and rate preference, although there is a

suggestion in the fact that two of the most "musical" subjects showed the most consistent preferences.

Before grouping was suggested, less than half the reactors had spontaneously grouped the clicks. A plurality of those who had been grouping grouped by fours, which was closely followed in popularity by threes and twos.

Comparison of Preferred Rates with Tapping Rates

Dunlap collected some data in 1934 on preferred rates for tapping groups of threes. Each reactor tapped threes for six trials of one minute. The reactor tapped on a Hopkins master key such as is used for making reaction time responses. This key was connected with one of four counters. By means of a commutator arrangement one counter was connected for 15 seconds and then another to get at any change of rate within the minute. Pulse rates were taken, but no connection was found between changes in pulse and tapping rate.

Nine of Dunlap's reactors also served in this experiment on preferred rates. Consequently a comparison is possible between preferred rates of tapping threes and preferred rates of clicks grouped by threes. One of nine subjects chose almost identical rates in the

TABLE 4

Comparison of Preferred Rate of Tapping Threes with Rate Preferred When Clicks are Subjectively Grouped in Threes

Both measures are in units per second

	Tapping	Clicks
VCJ	1.7	1.6
FMc	2.1	5.7
CEW	2.3	2.7
Ekl	2.5	4.0
MC	2.7	6.3
PG	3.4	5.2
SL	3.6	4.0
CDL	4.2	4.9
Gra	4.5	3.2

Correlation by the Spearman rank-difference method, +0.16.

TABLE 5

Comparison of Walking Time with Preferred Rate of Clicks When There was No Suggestion of Grouping

Walking time is in seconds; preferred rate is in clicks per second.

	Walking time	Preferred rate
SF	15.6	2.1
RBB	22.0	4.1
PG	23.4	6.5
AKB	24.8	3.0
CDL	25.2	4.9
ETM	26.0	4.2
RB	26.8	1.9
CEW	26.8	1.4
HP	29.0	1.8
FMc	29.4	8.7
DH	40.0	5.0

Correlation by the Spearman rank-difference method, —0.09.

two situations, but only two other subjects made similar choices under the two conditions. The correlation between rate of tapping threes and preferred rate of listening to subjectively grouped threes for the nine subjects was +0.16 (Table 4).

The Relation of Walking Speed to Preferred Rate

Eleven subjects were timed with a stop watch as they walked a certain distance in a long corridor. The subjects did not know that they were being timed. Their walking speed correlated —0.09 with their preferred rate (Table 5). This preferred rate was taken from five trials with no suggestion of grouping. If there were two or more identical choices the mode was used, otherwise the median of the five choices was used.

Preferred Rates of Music and Waltzing

It was noted that large individual differences existed for preferred rates and that differences occurred between a person's choice from one day to another. In those cases where the reactor revealed that his choices were the outcome of some definite association these differences were not so great as when the choice had no assignable basis. What happens to these individual and intra-individual differences when the subjects are told to do the same thing, e.g., to designate their rate of singing a particular song, preferred rate of hearing a piece of music, preferred rate of waltzing?

On each of three days 12 subjects designated (*a*) the rate at which they preferred to sing "The Star Spangled Banner"; (*b*) the rate at which they liked to waltz; (*c*) the rate at which they would like best to hear the jig, "Turkey in the Straw." The choice was made each time after hearing the oscillator's slowest rate. In the cases where the subject did not remember "Turkey in the Straw" the experimenter whistled the tune. All the subjects then said that they remembered the tune.

Five Chopin waltzes with metronome markings were used as a basis of comparison with actual waltz tempo. One of the waltzes changed in tempo from 1.6 to 2.93 beats per second. The other four waltzes had tempos of 1.8, 2.3, 2.4, and 2.53 beats per second. The metronome markings were for the number of quarter notes per minute, but the present method of expressing the tempos is used to facilitate comparison with our results.

The average rate preferred for singing "The Star Spangled Ban-

ner" was 2.84 beats per second, *MV* 0.74; waltzing, 2.56 beats per second, *MV* 0.93; and for hearing "Turkey in the Straw," 4.50 beats per second, *MV* 1.05 (Table 6).

When the separate trials on the three days are averaged and the subjects' preferences are ranked according to speed, the correlation was +0.63 between the rates indicated for singing "The Star

TABLE 6

PREFERRED RATES FOR SINGING "THE STAR SPANGLED BANNER," WALTZING, AND HEARING "TURKEY IN THE STRAW"

	"Star Spangled Banner"			Waltz			"Turkey in the Straw"		
FMc	2.9	4.6	4.5	4.2	5.7	4.8	6.2	6.3	6.0
MR	1.8	2.6	2.7	1.6	1.3	1.1	2.8	3.9	3.5
WR	2.1	1.8	2.6	2.0	2.6	2.6	4.2	4.0	5.1
CEW	0.9	2.0	2.2	0.9	1.2	1.3	2.6	2.7	2.6
TWZ	2.6	2.9	3.7	1.6	1.3	1.0	4.4	4.3	5.3
PG	5.0	4.3	4.4	4.3	4.6	3.3	5.6	6.0	5.4
HP	1.5	2.2	1.8	1.6	2.5	1.7	3.3	3.6	3.0
CDL	1.9	2.4	2.2	2.3	2.7	2.7	4.0	4.0	3.9
Gra	2.9	2.9	2.8	2.0	2.2	2.9	3.2	3.8	3.5
MC	3.0	3.0	2.2	2.0	1.9	2.1	6.6	6.2	5.9
VCJ	1.9	1.9	1.9	1.8	1.5	1.7	2.9	2.6	2.7
Ekl	3.8	5.5	4.7	3.8	6.0	5.6	6.3	7.3	7.7
Av.		2.84			2.56			4.50	
MV		0.74			0.93			1.05	

TABLE 7

AVERAGES AND MEAN VARIATIONS OF PREFERRED RATES FOR SINGING "THE STAR SPANGLED BANNER," WALTZING, AND HEARING "TURKEY IN THE STRAW"

	"Star Spangled Banner"		Waltz		"Turkey in the Straw"	
	Av.	MV	Av.	MV	Av.	MV
FMc	4.0	0.7	4.9	0.5	6.2	0.1
MR	2.4	0.4	1.3	0.2	3.4	0.4
WR	2.2	0.3	2.4	0.3	4.4	0.4
CEW	1.7	0.5	1.1	0.2	2.6	0.03
TWZ	3.1	0.4	1.3	0.2	4.7	0.4
PG	4.6	0.3	4.1	0.5	5.7	0.2
HP	1.8	0.2	1.9	0.4	3.3	0.2
CDL	2.2	0.2	2.6	0.2	4.0	0.03
Gra	2.9	0.03	2.4	0.4	3.5	0.2
MC	2.7	0.4	2.0	0.1	6.2	0.2
VCJ	1.9	0.0	1.7	0.1	2.7	0.1
Ekl	4.7	0.6	5.1	0.9	7.1	0.5
Av.		0.34		0.33		0.23

Spangled Banner" and waltzing; +0.85 between tempo of singing "The Star Spangled Banner" and hearing "Turkey in the Straw"; +0.70 between rate of waltzing and hearing "Turkey in the Straw." The relation between the subject's actual rate of waltzing and the rate of clicks he designated for the waltz is unsolved; likewise, we do not know this relation for the other two types of activity.

The variations of the subjects were slightly greater for "The Star Spangled Banner" than for waltzing (Table 7). The variations for preferred rate of hearing "Turkey in the Straw" was less than either of these. This order of variation is the reverse of that mentioned above for differences between subjects.

Three of the 12 subjects chose waltz rates faster than waltzes are actually played and three chose rates slower than the usual rate.

Effect of Fatigue and Whiskey on Preferred Rate

If the preferred rate is determined by changes in physiological conditions of the organism, one would expect a fatigued person to choose a slower rate than that which he would choose if not fatigued; and one might further predict that a person stimulated by a small dose of whiskey would select a faster rate than he would if not so stimulated.

The subject was instructed to adjust the oscillator to his preferred rate. He was then told to turn the crank of a large revolving device. The rate of turning was indicated by a metronome which was set at 40 beats per minute. The subject again selected the rate which he preferred after five minutes of turning the crank. Subsequently the subject drank two ounces of 93 proof straight Bourbon whiskey. After five minutes of conversation the subject again selected his preferred rate. All three of the choices were made by moving the sliding arm from the end of the rheostat giving the slowest rate. Each time *s*2 was placed at a different position so that the same rate would be found at a different place on *R*1.

Five minutes of turning a crank and drinking two ounces of whiskey produced no significant effect on the subject's preferred rate. On the day of this experiment the average of the original preferred rates was 3.29 per second; after "fatigue," 3.42 per second; after taking a drink of whiskey, 3.42 per second (Table 8). The subjects' choices under these three conditions were more consistent than they had been for three choices of preferred rate on one day when the only variable was the initial rate.

TABLE 8
EFFECT OF FATIGUE AND WHISKEY ON PREFERRED RATE

	Original	Fatigue	Whiskey	Average	MV
RBB	2.35	2.26	2.22	2.28	0.05
ETM	3.24	3.07	3.00	3.10	0.09
FJ	9.00	9.34	9.67	9.34	0.22
DH	3.20	4.14	3.80	3.71	0.34
CDL	2.55	3.07	2.64	2.75	0.21
AKB	2.77	2.77	3.04	2.86	0.12
TWZ	3.24	4.00	3.04	3.43	0.38
RB	1.31	1.09	1.69	1.36	0.22
HP	3.54	3.04	3.00	3.19	0.23
CEW	1.66	1.38	2.07	1.70	0.24
Av.	3.29	3.42	3.42		

Perhaps larger doses of alcohol or more strenuous fatigue would change the preferred rate. Five minutes is not long enough to secure the maximal effect from alcohol, but experimenters have shown some influence on other kinds of activity five minutes after administration.

When considering the effect of whiskey upon rhythm one has to take into account the reports of many people who maintain that they can dance better after taking several drinks. Is this true, or is it an illusion? If it is true, is it due to superior rhythmic perception, or to relaxation? If it is true, our assumption is that the latter explanation would be the correct one.

MEMORY FOR RATES

The apparatus was the same condenser discharge oscillator which was used for the rate preference determinations, in the experiments on memory for rates. A cardboard screen was clamped on the table in front of *R2* so that the reactor could not see *R2* when seated at the table. In this way a position of *s*1 would correspond at different times to different rates by changing the adjustment of *s*2.

The reactor was asked to sit down and put on the phones. The experimenter moved *s*1 up and down to demonstrate to the reactor how this changed the click rate. The experimenter then asked the reactor to move *s*1 to "get the feel" of moving the rheostat arm. The experimenter explained further:

> You will hear clicks at a certain rate, and then a little later you will try to find the rate which you heard by moving this

slider. If you judge by the position of the slider you will be misled, so make our judgments only on the basis of rate.

The experimenter demonstrated how he might change *s*2 so that the same setting on *s*1 would give a different rate.

Four rates, one, two, five, and eight clicks per second were used as standards. Sixteen trials were made in which each of the standards was presented four times on each of three days. The reproductions of each rate occurred as often from the end of the rheostat giving the fastest rate as from the end giving the slowest rate. In some cases no discharge was audible if *s*2 was set so that there was not

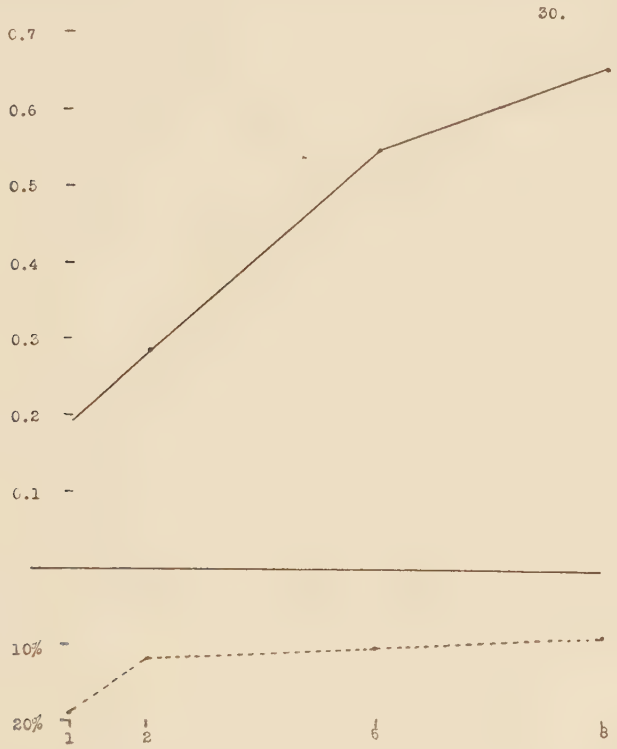

FIGURE 5

ERRORS IN REPRODUCING RATES

The solid line shows the errors in fractions of a click per second. The broken line shows the errors in percentage of the standard rate.

sufficient voltage to ignite the bulb with the particular setting of *s*1. The order of the standards was irregular on each day but the same order was followed on each of the three days. Changes of *s*2 between standard and reproduction were made according to a schedule. The standard was on for 30 seconds, and after 30 seconds more, the reactor attempted to reproduce the rate.

The absolute errors increased as the standard increased from one to eight per second. The average errors in clicks per second were, for one per second, 0.18; for two per second, 0.27; for five per second, 0.55; for eight per second, 0.67 (Figure 5). The per cent of the

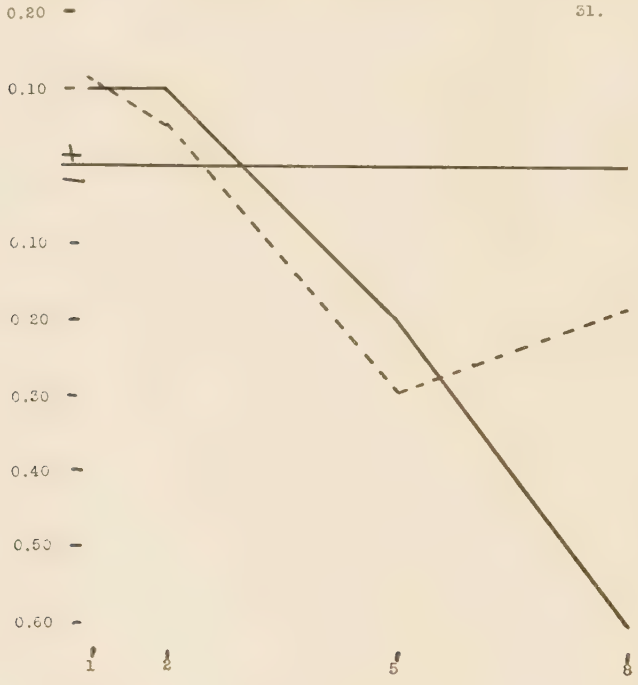

FIGURE 6

DIRECTION OF ERRORS IN REPRODUCING RATES

The solid line is for trials begun with the oscillator at slow rates. The broken line is for trials begun with the oscillator at fast rates. Points above the base line show that the reproduction was faster than the standard, while those below the base line are for reproductions slower than the standard. The ordinate is in clicks per second. The curves are the average results of 14 subjects.

errors is fairly constant except for the slowest rate which has the largest percentage error. The errors taken as per cent of the standards were, for one per second, 18 per cent; for two per second, 14 per cent; for five per second, 11 per cent; for eight per second, 8 per cent.

Practice did not enable the reactors to make more accurate reproductions of rates.

Some reactors were apparently influenced more than others by the rate at which the attempted reproduction was begun. The underestimations for the eight clicks per second standard were appreciably greater than estimations for the other standards when the reproduction was begun with the oscillator yielding slow rates (Figure 6). The reproductions of one and two per second tended to be faster than the standard, while the reproductions of five and eight per second tended to be slower than the standards (Table 9).

TABLE 9

MEMORY FOR RATES

The rate was heard for 30 seconds. The attempted reproduction was begun 30 seconds after the stimuli had ceased.

	Slow						Fast					
	Standard, one click per second											
	Trial						Trial					
	1	2	3	4	5	6	1	2	3	4	5	6
DH	1.2	1.2	1.2	1.3	1.3	1.0	1.1	1.2	1.2	1.1	0.9	1.0
Bal	1.3	1.0	1.0	1.1	1.0	1.3	1.2	1.0	1.3	1.3	1.3	1.1
AKB	1.1	1.2	0.9	1.0	0.9	0.9	1.1	1.2	1.0	0.9	0.9	1.1
HP	1.1	1.2	1.3	1.3	1.3	1.1	1.2	1.3	1.3	1.0	1.3	0.9
FJ	0.9	0.9	1.0	0.9	1.0	1.0	0.9	1.0	1.0	1.2	1.4	0.9
VK	1.6	1.3	1.4	1.4	1.2	1.0	1.3	1.3	1.3	1.1	1.0	1.0
TWZ	1.2	0.9	0.7	0.9	0.8	0.8	0.9	1.3	0.9	0.9	0.9	0.9
CEW	0.8	1.3	1.0	1.3	1.0	1.3	2.0	1.3	2.0	1.2	1.4	1.0
CDL	0.9	1.0	1.2	1.3	1.3	1.4	1.1	1.3	1.1	1.0	1.4	1.3
RBB	0.8	0.9	1.2	1.3	1.3	1.4	1.0	0.9	2.4	1.5	1.4	1.1
ETM	1.0	0.9	0.9	0.8	0.9	1.0	1.0	0.8	0.9	1.0	0.9	0.9
MB	1.3	0.9	1.3	1.1	0.9	1.4	1.0	1.0	1.3	1.1	0.6	0.9
Cla	0.9	0.9	1.1	1.3	1.0	1.4	1.1	0.9	1.3	1.2	1.4	0.9
Mal	0.9	1.0	1.0	1.0	1.1	1.2	1.0	0.9	1.0	0.9	1.1	1.0
Av.	1.1	1.0	1.1	1.1	1.1	1.2	1.1	1.1	1.3	1.1	1.1	1.0
			1.10						1.13			
	Standard, two clicks per second											
DH	2.0	2.6	2.2	2.5	1.9	2.1	2.7	1.5	1.9	1.7	1.7	1.8
Bal	1.9	1.9	2.2	3.0	2.1	2.0	2.0	1.9	1.9	1.9	1.7	1.9
AKB	2.3	2.1	2.1	2.0	1.7	1.9	2.2	2.0	2.1	2.1	2.3	1.7

TABLE 9 (*continued*)

	Slow						Fast					
	Standard, two clicks per second											
	Trial								Trial			
	1	2	3	4	5	6	1	2	3	4	5	6
HP	2.3	3.6	2.2	2.3	2.2	1.9	2.7	1.9	2.5	2.1	1.7	2.0
FJ	2.5	2.0	1.9	1.9	2.1	1.8	1.9	1.9	1.8	1.7	1.9	2.0
VK	3.0	2.2	1.9	1.9	1.7	2.1	1.9	2.1	1.9	1.9	1.9	2.1
TWZ	1.9	2.2	1.9	2.1	1.6	1.7	2.0	1.7	1.7	1.7	1.7	2.0
CEW	2.1	2.3	2.1	2.5	1.7	2.8	2.6	2.2	3.4	2.9	1.9	2.1
CDL	2.3	2.4	2.2	2.1	2.1	2.2	2.3	2.5	2.2	2.3	2.0	2.1
RBB	1.6	2.1	3.2	2.5	2.5	2.1	1.9	2.1	2.6	2.5	2.5	2.7
ETM	2.0	1.7	1.7	1.8	1.9	1.8	2.1	1.7	1.5	1.7	1.7	1.8
MB	2.6	1.7	2.4	1.7	1.8	1.9	2.6	1.8	2.0	1.7	2.0	2.0
Cla	2.2	2.0	1.9	1.9	2.5	2.1	2.1	1.9	2.1	1.7	2.8	4.1
Mal	1.7	1.9	1.8	2.1	1.9	2.3	2.0	1.6	1.7	2.6	1.7	1.9
Av.	2.2	2.2	2.1	2.2	2.0	2.1	2.2	1.9	2.1	2.0	2.0	2.2
			2.10						2.06			
	Standard, five clicks per second											
DH	4.3	5.0	4.6	4.8	5.2	5.2	4.9	3.3	3.6	4.2	4.7	4.4
Bal	5.6	5.0	4.9	5.0	5.2	4.5	5.3	4.6	4.6	4.7	4.6	4.7
AKB	4.9	3.6	4.5	3.8	4.3	3.6	5.2	4.6	5.9	4.7	4.5	4.5
HP	6.0	4.6	4.9	4.6	4.9	4.6	4.7	4.9	4.5	4.0	3.4	4.1
FJ	5.5	4.8	4.9	5.2	4.9	5.1	4.5	4.2	4.7	5.5	4.7	4.1
VK	4.7	5.6	5.3	2.7	5.0	5.0	4.6	5.6	2.5	1.9	4.0	5.9
TWZ	5.5	4.5	5.1	5.4	5.4	4.4	5.0	3.0	4.9	4.4	4.0	4.5
CEW	5.5	5.1	5.2	4.0	4.1	3.8	4.5	4.4	5.2	4.7	4.8	4.6
CDL	5.4	4.9	5.3	4.7	5.2	5.4	5.0	4.8	5.3	5.2	5.4	5.9
RBB	5.2	5.7	4.8	3.1	6.2	4.5	5.7	5.7	5.7	2.2	4.2	3.5
ETM	4.7	4.8	4.9	4.3	4.9	4.0	4.7	4.4	4.8	5.4	5.2	5.4
MB	5.2	5.2	4.9	4.7	4.7	4.5	6.8	5.2	5.0	7.1	4.3	3.8
Cla	4.2	3.9	4.8	4.7	4.3	4.5	4.9	4.1	6.1	4.7	4.7	4.2
Mal	4.6	4.7	5.0	4.8	5.2	4.5	4.5	5.0	4.9	5.5	4.9	4.8
Av.	5.1	4.8	5.0	4.4	5.0	4.6	5.0	4.6	4.9	4.5	4.6	4.7
			4.80						4.70			
	Standard, eight clicks per second											
DH	5.4	6.6	5.9	8.2	7.9	6.4	7.6	6.8	6.8	6.1	8.9	7.2
Bal	7.7	7.9	7.4	7.2	7.2	6.5	7.8	7.8	7.8	7.7	7.4	7.5
AKB	5.5	5.5	7.5	6.2	6.1	5.9	9.2	8.4	7.7	8.3	7.5	7.7
HP	7.5	8.1	6.9	7.2	6.9	5.9	8.1	7.5	7.4	7.7	7.9	8.7
FJ	7.8	8.0	7.7	7.6	7.6	7.1	9.8	7.7	7.7	8.2	7.6	7.4
VK	7.8	8.4	7.5	7.4	8.1	7.7	7.8	8.6	7.9	7.7	7.5	8.1
TWZ	8.6	7.4	7.5	8.5	6.9	7.5	8.3	6.2	7.4	5.2	7.8	6.2
CEW	6.7	7.4	7.7	6.4	8.5	7.1	7.4	7.7	7.8	7.8	7.7	8.6
CDL	7.9	7.6	8.6	7.3	7.5	8.0	8.2	7.6	8.2	8.4	9.1	8.3
RBB	8.3	5.9	7.8	8.8	5.4	7.2	8.0	9.0	7.8	9.3	9.0	8.3
ETM	8.2	8.0	7.6	7.7	7.8	7.3	6.6	8.1	7.4	7.5	6.9	7.1
MB	6.9	7.6	7.8	7.2	8.2	8.1	9.0	8.1	8.3	7.8	8.4	7.9
Cla	7.1	6.2	7.2	6.7	6.9	6.9	7.8	7.1	6.5	7.0	7.7	7.8
Mal	8.2	7.9	8.6	8.7	7.8	8.1	8.7	8.4	8.0	8.4	7.8	8.3
Av.	7.4	7.3	7.6	7.5	7.3	7.1	7.7	7.8	7.6	7.7	8.0	7.8
			7.37						7.82			

Rhythmic responses by the reactors were noticed frequently while the reactors were listening to the clicks. Such activity rarely ever occurred with the fastest rates. Examples of such activity were nodding the head, tapping the foot, or tapping the hand.

There was no observable connection between musical training and ability to remember rates. Six of the 14 subjects had taken the Seashore Test for Musical Talent (28). Their rank-difference correlation between the Seashore rhythm test and accuracy in reproducing rates was +0.39 (Table 10).

TABLE 10

COMPARISON OF SEASHORE RHYTHM TEST SCORES WITH ACCURACY IN REPRODUCING RATES

	Accuracy rank	Seashore score
FJ	1	82
ETM	2	80
MB	3	86
VK	4	68
AKB	5	82
DH	6	72

Spearman rank-difference correlation, +0.39.

In answer to the question, "How did you remember the rate?" the subjects replied as follows:

MB. The slower ones by grouping. Maybe all grouped by twos, threes, fours and indefinite above. Grouping was made before there was any suggestion of it.

CEW. In slow ones, tried to tap out with finger, don't tap continually during intermission, but some. Counted fours, twos; fast ones by fours. Couldn't count the very fastest ones. Tried to get image of sound of fast ones. There was a sense of familiarity to all when trying to reproduce a rate.

DH. Whatever they suggested, train, clock, etc., or say some phrase to time; sometimes beat fingers or foot.

Mal. Grouped in twos: usually fours before grouping was suggested.

Cla. Tried to concentrate; just remember and then duplicate. Grouped some.

CDL. Count as high as possible between clicks by fives, threes, tens; rate of eight per second reminded him of motor boat. Fast ones easier to find.

Bal. Fast ones were easier to pick; no method; didn't.

FJ. If it fitted in, grouped with breathing, associations, e.g., train. Usually counted to group; accented first in case of threes only.

VK. By thinking mentally; counted slower ones; tried to get mental feeling of faster.

TWZ. Attempted by setting up some type of rhythmic response which did not continue during resting period and checked memory against this, e.g., big toe; eye movements around quadrilateral; head bobbing; to fast rates, couldn't react to it in any such gross manner. Just remembered.

ETM. Grouped by fours when possible.

Memory for Rates after Varying Intervals

The subject sat in front of rheostat, *R*1 (Figure 1). A blindfold of 2-ply velvet was tied around his eyes. The experimenter told the subject that he would hear a rate, and afterwards he was to try to find the rate, by moving the rheostat arm. The experimenter closed the switch to start the clicks and at the same time he pressed a switch to start a stop-clock. After 30 seconds the experimenter opened the switch which stopped the clicks, and moved the rheostat arm to its extreme position on the subject's left. Five seconds before the interval was up (except for the five-second interval, during which this same act was performed) the experimenter placed the subject's right hand on the rheostat arm. The experimenter closed the switch to start the clicks at the expiration of the interval, and said "go." The oscillator was initially set at a voltage giving the slowest rate of clicks, or at a voltage which was too low to produce any clicks. Half of the subjects were not blindfolded. The same procedure was used for those five who were not blindfolded as that used in memory for different rates. The experimenter made a record of the voltmeter reading and stopped the clicks when the subject indicated that his judgment had been made. The experimenter set the oscillator at different times for 11 clicks per second, 7.5 clicks per second, 2.7 clicks per second, and 0.7 clicks per second. Reproduction was attempted for each of these four rates after 5 seconds, 30 seconds, 60 seconds. The order of the trials was arranged by chance.

Similar procedures were followed when the length of presentation time was varied. The standard rates were the same as when the interval between presentation and reproduction was varied, 11, 7.5,

2.7, and 0.7 clicks per second. Each of these rates was presented to each of 10 subjects for 2, 5, 10, 15, and 30 seconds.

A marked decrease in accuracy was found only in the case of the shortest interval, for the four "standard" rates, 11, 7.5, 2.7, and 0.7 clicks per second when the time between presentation and reproduction was either 5 seconds, 30 seconds, or 60 seconds. The average errors after the 5-second, 30-second, and 60-second intervals were 0.51, 0.73, and 0.68 clicks per second respectively (Tables 11 and 12).

TABLE 11

REPRODUCTIONS OF RATES WHEN THE TIME BETWEEN PRESENTATION AND REPRODUCTIONS IS VARIED

Units are in clicks per second.

	Standard rate											
	11.0			7.5			2.7			0.7		
	Interval between presentation and reproduction											
	5 sec.	30 sec.	60 sec.	5 sec.	30 sec.	60 sec.	5 sec.	30 sec.	60 sec.	5 sec.	30 sec.	60 sec.
RH	11.5	11.3	12.5	7.4	8.0	8.0	3.4	2.7	2.2	0.8	1.3	1.2
FJ	10.0	11.5	10.3	7.3	7.2	6.3	2.6	2.6	3.0	0.6	0.6	0.6
DH	11.7	10.3	10.0	6.4	6.3	4.2	2.4	2.7	2.7	0.6	0.6	0.5
Sau	10.2	9.2	11.0	6.9	6.3	6.3	2.7	2.3	2.6	0.7	0.8	0.8
PG	10.6	11.5	11.0	7.3	7.6	7.5	2.7	2.7	3.0	0.6	0.8	0.6
CEW	11.8	10.4	10.4	7.8	6.3	7.0	2.8	2.7	2.8	0.7	1.0	0.9
TWZ	10.6	8.4	8.9	6.3	6.5	7.3	2.7	3.0	3.5	0.6	0.6	0.8
WR	9.0	8.5	7.9	6.0	6.3	6.6	2.9	2.5	3.1	0.7	0.7	0.7
FMc	9.5	7.4	11.1	6.7	5.6	6.5	1.9	1.9	1.9	0.7	0.8	0.8
MR	9.3	8.8	8.4	6.0	6.3	6.0	2.9	3.3	3.2	0.8	0.8	0.8
Av.	10.4	9.7	10.15	6.8	6.6	6.6	2.7	2.6	2.8	0.68	0.8	0.77
		10.10			6.67			2.70			0.75	

TABLE 12

DIRECTION OF ERRORS IN THE REPRODUCTION OF RATES WHEN THE TIME BETWEEN PRESENTATION AND REPRODUCTION IS VARIED

The figures are the totals for 10 reactors in clicks per second.

	Interval between presentation and reproduction										
	5 seconds			30 seconds			60 seconds				
Standard rate	+	—	T	+	—	T	+	—	T	Av.	%
11.0	2.0	7.8	9.8	1.3	14.0	15.3	1.6	10.1	11.7	1.23	11
7.5	0.3	7.2	7.5	0.6	9.2	9.8	0.5	9.8	10.3	0.92	12
2.7	1.2	1.2	2.4	0.9	1.5	2.4	2.4	1.4	3.8	0.29	11
0.7	0.2	0.4	0.6	1.3	0.3	1.6	1.1	0.4	1.5	0.12	17
Total	3.7	16.6	20.3	4.1	25.0	29.1	5.6	21.7	27.3		
Average			0.51			0.73			0.68		

TABLE 13

REPRODUCTIONS OF RATES WHEN THE PRESENTATION TIME WAS VARIED

The units are in clicks per second.

Standard rate	Time exposed	RH	FJ	DH	Sau	RBB	ETM	CDL	MC	VCJ	FMc	Av.
	30	11.9	10.0	10.0	10.7	11.0	9.5	10.5	9.8	10.9	12.0	10.63
	15	12.0	9.3	10.3	9.7	11.1	9.4	10.4	8.9	9.7	10.6	10.14
11	10	11.2	10.5	10.3	11.3	10.0	9.8	10.3	9.3	9.4	9.8	10.19
	5	10.0	9.9	10.4	11.9	10.5	9.9	10.2	6.8	9.1	9.2	9.79
	2	11.0	9.9	10.3	11.9	10.9	9.8	9.8	9.2	10.2	9.1	10.21
												10.19
	30	8.0	7.2	6.7	6.6	7.7	6.2	7.5	7.0	7.9	7.6	7.24
	15	8.0	7.0	6.4	8.0	8.4	6.1	8.6	6.7	7.5	6.0	7.27
7.5	10	7.7	6.9	6.3	8.0	7 0	7.2	7.2	6.4	7.6	6.3	7.06
	5	7.7	5.8	6.3	7.0	7.6	6.5	7.1	7.8	7.1	6.1	6.90
	2	7.0	6.9	6.4	8.7	7.0	6.3	6.3	6.1	8.0	7.6	7.03
												7.10
	30	3.0	2.7	2.7	2.7	3.1	2.7	2.3	2.9	2.6	2.5	2.72
	15	2.9	2.7	2.9	2.8	3.0	2.3	3.0	2.0	2.7	2.8	2.71
2.7	10	2.7	2.6	2.4	2.7	3.2	2.5	2.7	2.0	2.5	2.1	2.54
	5	2.5	2.4	2.3	2.8	2.8	2.7	2.8	2.2	2.4	2.5	2.54
	2	2.1	2.5	3.3	2.8	3.0	2.4	2.5	2.5	2.2	2.1	2.54
												2.61
	30	1.1	0.8	0.8	0.8	1.0	0.7	0.7	0.7	0.9	0.9	0.84
	15	1.2	1.0	0.6	0.8	0.9	0.6	0.7	0.8	0.7	0.7	0.80
0.7	10	1.1	0.8	0.8	0.8	1.0	0.8	0.7	0.7	0.7	0.9	0.83
	5	0.7	0.8	0.8	0.8	0.6	0.9	0.7	0.9	0.8	0.8	0.78
	2	1.1	1.4	0.6	0.8	0.5	0.8	0.8	0.9	0.9	1.5	0.93
												0.84

The absolute size of the average errors increased with the speed of the rate to be reproduced. When the errors are figured in terms of per cent of the standard, the errors are practically the same except in the case of the slowest rate which has the highest percentage error. The percentage errors for the different rates in order from slowest to fastest was 17, 11, 12, and 11.

The tendency to change from a slight overestimation at the slowest rate to an underestimation of the faster rates is shown in the average reproductions. Rate 0.7 was estimated as 0.75; rate 2.7 as 2.7; 7.5 as 6.67; 11.0 as 10.10.

It appears as if the rate of 2.7 clicks per second (or stated another way, one click every 0.37 seconds) was the "indifferent rate," or the rate at which the overestimations were equal to the underestimations. Our other results are not entirely consistent in the location of this indifference rate, but the majority of the subjects locate it somewhere between the rates of two and three per second. Perhaps this should be called the preferred rate since it is the rate which subjects approach when they try to reproduce a rate faster or slower. The interval between clicks at this rate is shorter than that accepted as the indifference point in time estimation.

There is a tendency for the accuracy of reproduction to increase with the length of presentation for the presentation times used. The average errors in clicks per second were for 2 seconds, 0.61; for 5 seconds, 0.61; for 10 seconds, 0.48; for 15 seconds, 0.57; for 30 seconds, 0.39 (Tables 13 and 14).

TABLE 14

AVERAGE ERRORS IN THE REPRODUCTION OF RATES WITH VARYING LENGTHS OF THE PRESENTATION PERIOD

The figures represent the averages, in clicks per second, for the 10 reactors.

Standard rate	Length of the presentation period						
	30	15	10	5	2	Av.	Per cent of standard
11.0	0.75	1.08	0.91	1.39	0.97	1.02	9
7.5	0.50	0.83	0.60	0.72	0.83	0.70	9
2.7	0.16	0.22	0.26	0.22	0.36	0.24	9
0.7	0.14	0.14	0.13	0.10	0.29	0.16	23
Av.	0.39	0.57	0.48	0.61	0.61		

The size of the absolute errors increased with the speed of the rate to be reproduced, as is shown by the following figures: (the

standard rate is given first, followed by the average errors; both in clicks per seconds) 0.7, 0.16; 2.7, 0.24; 7.5, 0.70; 11.0, 1.02. The errors figured as per cent of the standard are the same (9%), for the three rates, 2.7, 7.5, and 11.0 clicks per second, while the percentage error for the 0.7 standard is 23.

The tendency to pass from overestimation of the slower rates, to underestimation of the faster rates is shown in the average reproductions. Rate 0.7 was estimated as 0.84; rate 2.7 as 2.61; rate 7.5 as 7.1; rate 11.0 as 10.19.

Influence of One Rate on Another

Dunlap had demonstrated the effect of subliminal stimulation in vision.[3] An experiment was undertaken to determine whether subliminal stimulation would be effective in audition. The apparatus was the same condenser discharge oscillator which was used in the preceding experiments. In order to change the loudness of the clicks the primary of a transformer was connected in place of the headphones. The headphones were connected to the secondary of the transformer in series with four fixed resistances (two 1,000,000 ohm, one 500,000 ohm, one 300,000 ohm), each of which could be separately short-circuited by closing a knife switch. Four circular rheostats (each having a resistance of 75,000 ohms), were also in series with the headphones and the secondary of the transformer. In this way enough resistance could be introduced to make the clicks imperceptible (there was one exception; one subject could hear clicks with all the resistance applied). If the transformer had not been used, and the resistance had been put in series with the original headphone circuit, the loudness could have been reduced, but the rate would also have been changed. The rate was not altered by different resistances in the secondary transformer circuit.

A threshold determination was made with each of the seven reactors, for each rate which was to be presented later subliminally. Greater resistance, as a rule, was required with increasing rate to reach the threshold. The clicks were clearly audible at first, and one by one the fixed resistances were inserted by closing knife switches. The subject signalled when he could no longer hear the clicks; the last resistance inserted was then removed, which restored

[3]He did this by demonstrating that sub-liminal shadows would produce the Müller-Lyer illusion.

the clicks to audibility, and a more exact determination was made by having the subject signal when he no longer heard the clicks as the experimenter added more and more resistance by turning the circular rheostats, one at a time. The thresholds determined in this manner are probably low because of the influence of suggestion. Thresholds were measured for the following rates (in clicks per second) 0.5, 1, 2, 3. The experimenter then told the subject that this was all of the threshold experimentation, and that an experiment similar to one performed several weeks previously, would be done next. The subject was instructed, "You will listen to clicks at a certain rate and a little later you will move this rheostat arm to locate the rate which you just heard." Standards of one and two clicks per second were each presented for 30 seconds. One minute after the cessation of the standard, the subject tried to reproduce the standard. After the one click per second standard, a subliminal presentation of either 0.5 or 2 clicks per second was made during the 30 seconds in the middle of the supposed silent period; i.e., the order was, standard on for 30 seconds, 15 seconds of silence, subliminal presentation for 30 seconds, 15 seconds of silence, attempted reproduction. One trial was made, as a control, with no subliminal advenient.[4] This control was also used with the standard of two clicks per second, where the subliminal rates were one or three clicks per second.

No effect could be found from the subliminal rates. A further problem arose from this negative finding. What is the effect of a clearly audible rate on one's accuracy in reproducing a previously heard rate? The negative findings in the case of the subliminal effect were not absolutely conclusive, but if no marked influence could be shown with rates above threshold, it would not seem worth while to continue subliminal experimentation. The same two standards, one and two clicks per second, were used. The subject was instructed in each case to remember the first rate which he heard. He was told that another rate might occur which could be either the same, or faster, or slower than the one which he was to reproduce. This was presented for 30 seconds, then one of four different conditions was followed for each standard. These were, for the one click per second standard: (*a*) no advenient; (*b*) a rate of one

[4]A term suggested by Dunlap to cover presentations to any sensory mode, whether of stimulating value or not.

click per second for 30 seconds at the same intensity as the standard, inserted in the middle of the interpolated minute; (*c*) clicks at the rate of 0.7 clicks per second for 30 seconds in the middle of the interpolated minute; (*d*) 1.3 clicks per second for 30 seconds in the middle of the interpolated minute. Similarly the standard rate of two clicks per second was followed during the interpolated minute by one of four conditions: (*a*) no advenient; (*b*) 30 seconds of the same rate as the standard, i.e., two clicks per second; (*c*) 1.7 clicks per second for 30 seconds; and (*d*) 2.3 clicks per second for 30 seconds. The intermediate rates never differed more than 30 per cent from the rate to be reproduced. This ratio was used since reactors ordinarily made some mistakes as great as 30 per cent in reproducing rates.

An intermediate rate had no effect upon the subject's accuracy in reproducing the standard rate, considering the averages. The average reproduced rate for the nine subjects for the one click per second standard was 1.1 clicks per second with intermediate rates of 1.0, 0.7, and 1.3 clicks per second, and also when there was no rate presented intermediately (Table 14*a*). The averages are almost as consistent for the 2.0 clicks per second standard. The average reproduced rate is 2.0 clicks per second when the intermediate rate was 2.0 per second; 1.70 clicks per second; and when there was no intermediate rate. The average rate reproduced was 1.9 clicks per second with an intermediate rate of 2.3 clicks per second.

These data suggest 2.0 clicks per second (one click in 0.5 second) as the "indifference rate," that is, the rate where the overestimations will balance the underestimations. Perhaps this indifference phenomena spreads over a range of rates instead of being located at any one rate.

There was no demonstrable effects from the subliminal stimulation. With a standard of one click per second, the average rate reproduced was 0.94 when no rate was presented intermediately; 1.06 with an intermediate rate of one click in two seconds; 1.08 when the intermediate rate was 2.0 per second (Table 15). When the standard was 2.0 clicks per second, the average rate reproduced was 2.11 with no interpolated rate; 2.6 with an interpolated rate of 1.0 per second; 2.04 with an interpolated rate of 3.0 per second.

Although the intensity threshold for clicks could be reached, a hum occurred which was not present at the usual intensity of the clicks.

TABLE 14*a*

REPRODUCTIONS OF RATE WHEN A SECOND RATE IS INTERPOLATED BETWEEN THE STANDARD RATE AND THE ATTEMPTED REPRODUCTION

	Standard rate 1.0				Standard rate 2.0			
	Interpolated rate				Interpolated rate			
	None	1.0	0.7	1.3	None	2.0	1.7	2.3
ETM	1.2	1.0	1.2	0.9	1.9	2.0	1.9	1.9
	1.0	1.0	1.0	1.1	2.0	2.0	1.8	1.6
RBB	1.0	1.0	0.9	1.3	1.6	2.1	2.1	1.9
	1.1	1.1	0.9	1.2	2.1	2.1	1.8	2.1
AKB	0.9	1.1	0.9	1.1	1.9	2.0	2.1	1.9
	1.1	0.9	0.9	0.9	2.1	2.1	1.9	1.7
Sau	1.1	1.2	1.2	0.9	1.8	1.9	1.9	2.1
	1.2	0.9	1.1	1.1	1.8	1.8	1.7	1.8
RH	1.1	1.1	1.0	1.2	1.9	2.0	1.7	1.6
	1.1	1.6	1.1	1.1	2.1		1.8	1.7
		1.1						
Mal	1.1	0.9	0.8	1.1	2.1	1.9	2.1	1.9
	0.9	1.1	1.1	1.1	2.0		2.1	2.3
		0.9						
TWZ	0.9	0.9	1.0	1.1	2.0	1.9	2.1	1.4
	1.0	0.9	2.0	0.9	2.1	2.5	2.0	2.2
CDL	1.1	1.1	1.0	1.1	2.0	2.3	2.3	2.0
	1.0	1.5	1.1	1.7	1.8	2.0	2.2	1.7
SF	1.1	1.3	1.0	1.1	3.0	2.2	3.0	2.8
	1.4	1.6	1.2	1.4	2.3	1.7	2.1	2.1
Av.	1.1	1.1	1.1	1.1	2.0	2.0	2.0	1.9
		1.1				2.0		

TABLE 15

MEMORY FOR RATES WHEN AN INTERMEDIATE RATE WAS PRESENTED SUBLIMINALLY

	Standard rate One click per second			Two clicks per second		
	Intermediate rate					
	None	0.5	2.0	None	1.0	3.0
Mal	1.0	1.0	0.9	2.1	2.0	2.0*
AKB	0.7	0.9	0.9	1.8	1.7	1.9
CEW	1.0	1.0	1.2	1.8	1.9	2.0
CDL	0.9	1.1	1.1	2.2	2.7	2.0
HP	1.3	1.6	1.5	3.0	2.3	2.4
DH	0.8	1.1	0.9	2.2	2.2	2.0
ETM	0.7	1.0	1.0	2.2	2.3	2.2
RBB	1.0	0.9	1.2	1.7	2.2	1.9
FJ	1.1	0.9*	1.0	2.0	2.1	2.0
Average	0.94	1.06	1.08	2.11	2.16	2.04

*Threshold not reached.

This disturbing factor is the reason that more threshold experimentation was not done.

Memory for Rhythm with Different Responses

When rates were being remembered with no instructions as to the method of memory, the majority of the subjects made overt rhythmic responses, e.g., tapped with the foot or hand, or moved the head. Still others revealed subvocal activity as an accompaniment of the rhythmic perception. Are these responses beneficial or necessary for the memory of rhythm? If they are beneficial, which responses are most beneficial? Motor activity has frequently been mentioned as being essential for rhythm. The elimination of all responses mentioned does not eliminate implicit muscular activity. Further, it might be possible to remember rates with no perception of grouping.

Four responses usually used in "keeping time" and two unusual responses were selected. The reactor, in each case, was told to group the clicks by fours and to respond with the first click in each group. Grouping by fours was chosen because it was named by the majority as being the most "natural." The responses were continued during the interpolated silent period and until the subject had made his judgment of the rate which he had just heard. Memory for each of three rhythms was obtained under seven different sets of instructions: (*a*) no instruction as to method; (*b*) counting the clicks by groups of four with an accent on the first click in every group; (*c*) tapping with the left hand; (*d*) tapping with the right foot; (*e*) moving the tongue to the roof of the mouth; (*f*) contracting the abdominal muscles; (*g*) inhibiting all rhythmic responses to the clicks, including counting. The subject's choice of a method in (*a*) was probably influenced in some cases by the experimenter's suggestions. There was no indication from the experimenter whether the accent in (*b*) should be one of duration or of intensity. The left hand was used in (*c*) so that the right hand would be free to move the rheostat arm. The experimenter does not know how well the subjects carried out the instructions. It would be possible to record some of them, e.g., hand or foot movements.

Although some subjects reported that occasionally they did not count, the presence of counting with the other "directed" responses complicated matters. Another series was carried out in which re-

sponses were made with each click. Counting was more easily suppressed in that procedure.

Three rates were presented to each subject when he grouped the clicks by fours. These rates were different for each subject and were: (*a*) the "preferred rate" as designated immediately before the memory series; (*b*) a rate faster by one click per second than (*a*); (*c*) a rate slower by one click per second than (*a*). In one case, (*b*) and (*c*) differed from (*a*) by only 0.5 click per second because the preferred rate was so slow that it was impossible to present a rate one click per second slower. The preferred rate was used as the standard to be reproduced to ascertain if it could be reproduced more accurately than neighboring rates. This provided a measure of the definiteness of the preferred rate.

In the series where the responses were made with each click, reproductions were made with four different instructions, "free," counting "one," tapping with the right foot, or contracting the abdominal muscles. The same four standards were presented to all subjects, and were 1, 1.4, 2, and 2.7 clicks per second.

The reactors were questioned as to their method when they could use any method they chose in remembering the rates. Their replies are summarized below:

	Rate			
	2.7	2.0	1.4	1.0
MB	counted 4s; no accent	counted 2s	counted 2s	counted 2s
VK	counted 4s; no accent	counted 4s; accented 1st	counted 4s; no accent	counted 4s; accented 1st
DH	counted 4s; accented 1st	did nothing	groups of 8 "bum . . ."	"boots . . ."
FJ	something like a clock	said "tick-tock"	said "tick-tock"	very unpleasant, slow
ETM	counted 4s	said "one, two"	counted	counted
RH	no method	counting 2s; and heart	no method	sub-vocal grunting
RBB	no method	counting 2s; and heart	no method	heart faster
AKB	4s; accented 1st and tapped toes	4s	4s	
CDL	break in breath hummed song	waved head	tapped on leg	waved head
SF	tapped foot; clucked	tapped hand	tapped hand	tapped hand

The preferred rate was not remembered better than rates one click per second faster and one click per second slower than the preferred rate. The average error in reproducing the preferred rate (in clicks per second), was 0.22, whereas for the slower rate it was 0.31,

TABLE 16

MEMORY FOR RATES WHEN A RESPONSE WAS MADE WITH THE FIRST CLICK IN EACH GROUP OF FOUR

The standards were the preferred rate, a rate one click per second slower; and a rate one click per second faster.

	PR	F	C	L	R	T	A	N*
RBB	2.5	2.5	2.3	2.2	2.1	2.6	2.7	2.7
AKB	2.7	2.9	3.0	2.9	3.0	3.0	2.6	2.6
Sau	2.0	2.0	2.0	2.1	1.9	2.0	2.3	2.1
TWZ	3.0	2.8	3.7	2.5	2.9	4.0	3.9	3.0
ETM	2.7	3.0	2.9	2.8	2.6	2.7	2.7	2.7
FJ	6.2	6.2	6.2	6.2	5.7	6.3	5.9	6.0
RH	1.4	2.5	1.6	1.8	1.9	1.5	1.7	1.5
DH	3.7	4.0	3.3	3.7	3.5	3.9	4.3	3.6
VK	5.3	4.9	5.6	5.5	5.4	5.4	5.4	5.6
MB	2.7	2.6	2.6	2.8	2.9	2.8	2.7	2.7
	PR—1							
RBB	1.5	1.7	1.4	1.6	1.7	1.7	1.9	2.2
AKB	1.7	2.0	1.8	1.8	2.0	1.7	2.0	1.8
Sau	1.0	1.1	1.1	1.4	1.3	1.6	1.3	1.1
TWZ	2.0	3.3	2.1	4.2	2.2	2.8	2.8	2.9
ETM	1.7	1.4	1.6	1.6	1.7	1.7	1.7	1.7
FJ	5.2	4.5	5.4	5.1	5.3	5.3	5.3	5.6
RH	0.9†	1.6	1.7	1.4	1.6	1.6	1.3	1.2
DH	2.7	3.0	3.0	2.7	2.6	2.9	3.2	2.8
VK	4.3	4.3	4.4	4.6	4.4	4.5	5.0	4.4
MB	1.7	1.7	1.5	1.6	1.7	1.7	2.3	1.5
	PR+1							
RBB	3.5	3.4	3.7	4.0	3.3	3.8	3.8	3.7
AKB	3.7	3.6	3.7	3.5	3.8	3.8	3.6	3.7
Sau	3.0	2.7	3.0	2.3	2.7	2.6	3.0	2.9
TWZ	4.0	4.0	4.6	4.0	4.4	3.8	3.0	4.2
ETM	3.7	3.7	3.8	3.8	3.7	3.6	3.4	3.7
FJ	7.2	7.1	7.0	7.1	7.3	7.0	7.1	6.7
RH	1.9†	2.5	1.9	2.0	2.1	2.2	2.0	1.9
DH	4.7	4.6	4.7	4.9	4.8	4.8	4.9	4.2
VK	6.3	6.2	6.4	6.1	6.2	6.2	6.3	6.3
MB	3.7	3.9	3.4	4.3	3.9	3.4	4.0	3.8

*The columns are arranged according to the responses accompanying reproductions; *F*, "free," i.e., the response was optional to the reactor; *L*, tapping left hand; *R*, tapping right hand; *T*, moving tongue; *A*, contracting abdominal muscles; *N*, relaxed, and making no muscular response.

†These rates differed by only 0.5 click per second from the preferred rate.

and for the faster, 0.19 (Table 17). This casts doubt upon the definiteness of the preferred rate.

TABLE 17

AVERAGE ERRORS WHEN RESPONSE WAS MADE WITH THE FIRST CLICK IN EACH GROUP OF FOUR

PR+1	0.16	0.15	0.27	0.17	0.21	0.21	0.16	0.19
PR	0.26	0.24	0.19	0.25	0.20	0.28	0.11	0.22
PR—1	0.39	0.21	0.39	0.20	0.28	0.41	0.29	0.31
Average	0.27	0.20	0.28	0.21	0.23	0.30	0.19	

*The columns are arranged according to the responses accompanying reproduction; *F*, "free," i.e., the response was optional to the reactor; *L*, tapping left hand; *R*, tapping right hand; *T*, moving tongue; *A*, contracting abdominal muscles; *N*, relaxed, and making no muscular response.

There was little difference in the average errors in reproducing rates, when various responses were made with the first click in each group of four. The average errors (in clicks per second), were, "doing nothing," 0.19; counting, 0.20; right foot, 0.21; tongue, 0.23; "free," 0.27; left hand, 0.28; abdomen, 0.30 (Tables 16, 17).

The motor responses did not make memory for rhythm more accurate. It is possible that if the subjects had had more practice with the responses, they might have been more accurate. It is rather striking that the greatest accuracy (although the differences are not statistically significant) was shown when the subject was instructed to do nothing. The reactors were relaxed during the time when they were instructed to "do nothing." This raised the question as to what the subjects were really doing. What would be the results if the subjects tensed their muscles instead of relaxing them?

The question of whether the subjects had rhythmic perception when they were "doing nothing" was not answered.

Four standard rates were used for each of the 10 reactors when responses were made with each click. These standards were, 1, 1.4, 2.0, and 2.7 clicks per second. The "directed" responses, here as well as when the responses were made with each of a group of clicks, did not produce any superior accuracy in reproduction. The comparative accuracy following the four types of instruction is shown by the following average errors (in clicks per second): "free," 0.14; counting, 0.18; right foot, 0.21; abdomen, 0.24 (Tables 18, 19).

TABLE 18

MEMORY FOR RATES, RESPONDING WITH EACH CLICK

	Standard rate 1.0				1.4			
	C	R	A	F	C	R	A	F*
RBB	1.1	1.1	1.2	1.0	1.7	1.9	1.7	1.4
AKB	1.0	0.9	0.9	0.9	1.4	1.5	1.3	1.4
CDL	1.2	1.1	1.6	1.0	1.7	1.4	1.5	1.7
SF	1.2	1.2	0.8	1.4	2.3	1.6	2.1	1.6
FJ	0.9	1.0	1.0	1.0	1.5	1.5	1.5	1.4
ETM	0.8	1.0	0.9	1.0	1.3	1.5	1.3	1.4
RH	2.2	1.4	1.9	2.1	1.7	2.4	2.2	1.9
DH	1.1	1.0	1.1	0.9	1.4	1.5	1.6	1.4
VK	1.1	1.1	1.1	1.0	1.5	1.3	1.7	1.3
MB	1.1	1.1	1.1	1.2	1.3	1.1	1.3	1.3
Av.	1.17	1.09	1.16	1.15	1.58	1.57	1.62	1.48
	Standard rate 2.0				2.7			
RBB	2.2	3.3	2.2	1.9	2.7	2.5	3.0	2.8
AKB	1.8	1.8	2.0	2.0	2.5	2.7	2.4	3.0
CDL	2.0	2.1	2.1	2.1	2.9	2.7	2.9	2.7
SF	2.3	1.9	2.5	2.3	2.6	2.6	2.7	3.2
FJ	2.0	2.2	2.3	2.0	2.7	2.5	2.1	2.7
ETM	1.9	1.8	1.8	1.6	2.7	2.6	2.6	2.5
RH	2.6	2.6	2.5	2.5	2.9	3.0	2.7	2.7
DH	2.0	3.0	2.3	2.1	2.7	2.5	3.0	2.8
VK	2.0	2.1	1.9	1.9	2.5	2.5	2.6	2.6
MB	2.0	2.4	1.8	1.7	2.2	2.7	2.6	2.3
Av.	2.08	2.32	2.14	2.01	2.64	2.63	2.66	2.73

*The columns are arranged according to the responses accompanying reproduction; *C*, counting; *R*, right foot; *A*, contracting abdominal muscles; *F*, "free," i.e., the response was optional to the reactor.

TABLE 19

REPRODUCING RATES WHEN THE RESPONSE WAS MADE WITH EACH CLICK

The figures represent the totals for 10 reactors.

Standard rate	Counting +	Counting −	Right foot +	Right foot −	Abdomen +	Abdomen −	Free +	Free −	Total	Av.
1.00	2.0	0.3	1.0	0.1	2.0	0.4	0.7	0.2	6.7	0.18
1.44	2.0	0.1	2.4	0.1	2.5	0.3	1.0	0.2	8.6	0.22
2.00	1.1	0.3	3.6	0.4	1.9	0.4	1.0	0.9	9.6	0.24
2.67	0.4	1.0	0.3	1.0	0.8	1.2	1.0	0.7	6.4	0.16
Total	5.5	1.7	7.3	1.6	7.2	2.3	3.7	2.0		
	7.2		8.9		9.5		5.7			
Av.	0.18		0.21		0.24		0.14			

The average errors for the different rates were (the rate is given first, followed by the average error, both in clicks per second): 2.7, 0.16; 1.0, 0.18; 1.4, 0.22; 2.0, 0.24 (Table 19).

The shift from overestimation to approximately correct responses with increase in rate is shown by the average reproductions. The standard rate of 1.0 click per second was estimated as 1.14; 1.4 per second as 1.56; 2.0 per second as 2.14; and 2.7 per second as 2.67. This shift, if the rates had been increased further, would have resulted in underestimations of faster rates, judging by our results in other experiments.

There were considerable individual differences in memory for rates. While most of the subjects' responses were fairly accurate, one subject (*RH*), never underestimated the standard on the 37 trials in these two series. He did reproduce the standard correctly twice, but his reproductions were faster than the standard on the other 35 trials. In order to determine whether this overestimation was due to the reproduction being begun from the slowest rate, a series was run in which the reproduction was begun from the fastest rate. This made no noticeable difference in the responses, as all of his responses were overestimations. This extreme case made the experimenter wonder if his errors were due to failure to synchronize with the standard, or were due to the response being speeded up during the waiting period. This problem might be studied by obtaining a simultaneous record of the clicks and the subject's tapping. In addition it would be necessary to secure a record of his rate of tapping while the clicks were not heard. The main difficulty would be in obtaining a record of the clicks, since the current usually employed is not enough to actuate a time marker. This might be overcome by having the headphones connected to the primary of the transformer with the secondary of the transformer connected to a balanced relay which would actuate a time marker.

Summary and Conclusions

Rhythm has been studied experimentally with auditory, visual, and electrical stimuli. It has also been investigated by having the subject make rhythmic muscular responses. Our investigation was primarily concerned with rhythm from auditory stimuli, and secondarily with overt rhythmic responses. The effect of physical changes in stimuli on auditory rhythm has been best worked out by

Woodrow. He found that intensity has a group-beginning effect; duration, a group-ending effect; pitch has neither a group-ending nor a group-beginning effect. Many investigators have reported that persons subjectively group uniform series of sounds. The question as to whether persons prefer any particular rate of auditory stimulation has been attacked, but it was thought desirable to experiment further upon this problem since the apparatus presented certain advantages over any previously used. The question of memory for rhythms was the second major problem studied. The several experimental series may all be grouped under the title, "Factors Influencing Preference and Memory for Auditory Rhythm."

Under the conditions of the experiment there was no one rate, or even fairly narrow range of rates which the majority of subjects chose. Although practically all subjects were fairly consistent in their choice from one trial to another, this choice does not seem to be a "pure, esthetic" preference, but is a definite association with some activity. It is doubtful if the "feeling tone," accompanying the rate chosen, was high for many subjects.

Fatigue and alcohol did not affect the preferred rate.

Subjects spontaneously grouped identical clicks. Grouping by fours seemed to be the most natural form, but the manner of grouping could be variously changed by suggestion.

There is practically no correlation between rate of tapping threes, and preferred rate of listening to clicks subjectively grouped by threes.

When clicks are subjectively grouped by twos, threes, fours, fives, or sixes, the preferred rate tends to increase with the size of the group, but the temporal length of the group also increases with the numerical size of the group.

Walking rate and preferred rate of listening to clicks had no correlation.

There was a high correlation between preferred rates for singing "The Star Spangled Banner," waltzing, and listening to "Turkey in the Straw."

Slow rates were overestimated, and fast rates were underestimated; there was an indifference range between two and three clicks per second.

The absolute size of error grew with the speed of the standard,

but the percentage error remained nearly constant, except at a standard below one click per second where it was larger.

The accuracy was affected both by the length of presentation, and the time between presentation and reproduction, but was not affected by an interpolated rate.

Six subjects showed a correlation of +0.39 between rankings on the Seashore test for rhythm and accuracy in reproducing rates.

Subjects were equally as accurate in reproducing rates if they tried to be passive, as when they made rhythmic responses. Counting and tapping with the right foot yielded the best results of the responses tried.

The condenser discharge oscillator may be useful in other experiments. If it is used for giving recurring stimuli, the stimulation may be visual as well as auditory.

Although definite preferences for a rate of stimulation have been mentioned previously, this is the first time that such preferences have been obtained on several different trials. No one has heretofore emphasized the factor of association in subjects' choices for a rate of auditory stimulation which is preferred. There is no uniform preference among individuals, consequently group averages for such preferences are of little value.

The traditional view, which was first advanced by Bolton, is that the absolute temporal size of a preferred rhythmic group is fairly constant. Bolton's results gave a slight decrease in temporal size of the group with increase in numerical size. Our results are opposite to those of Bolton, and show a definite temporal increase with neumerical increase of the group. One might look to a difference in methods for an explanation of these contradictory results, but there is no logical reason why the two methods should yield contradictory results. Bolton's procedure has been criticized by several experimenters, chiefly because he did not present the same rates to his different subjects. It seems safe to conclude that the absolute temporal extent of a preferred group increases slightly with numerical growth of the group. Our subjects agree with those of other experimenters that grouping by fours seems most natural.

Our negative results concerning any change in preferred rate occasioned by an altered physiological condition may be minimized by the fact that the physiological change was not great enough to show in the preference.

The reactors showed a definite preference for a rate in the sense that there was a high correlation between their choices from one trial to another. Two other measures failed to show any definiteness of preference. The preferred rate could not be reproduced more accurately than could neighboring rates. Intra-individual differences were greater for trials of choosing the preferred rate than for choosing a rate of some prescribed activity.

Many investigators have been interested in the problem as to whether a person who is fast in one activity will be similarly fast in another. The evidence here is consistent with the current status of the problem. There is no great relation between speed of performing acts, unless the actions studied are very similar. There was no correlation between preferred rate of tapping threes and preferred rate of listening to clicks grouped by threes. There was no correlation between speed of walking and preferred rate. On the other hand, there was a high correlation between the rates designated for preferring to sing "The Star Spangled Banner," waltz, and listen to "Turkey in the Straw." The accuracy of reproduction correlated +0.39 with rankings on the Seashore test for rhythm with six subjects.

Our results on memory for rates which show that slow rates are overestimated, fast rates are underestimated, and rates between two and three per second are overestimated as much as underestimated, are similar to the results of experiments on the investigation of time estimation. The indifference point for time estimation, although differing with experimental conditions, has always been longer than ours, (considered as the time between any successive pair of clicks). One might expect this since the judgments in time estimation are usually made by some gross rhythmic response.

Weber's law seems to hold, at least for a certain range, in reproducing rates. The absolute size of errors increases with the size of the rate to be reproduced, while the percentage errors remains practically constant. An exception to this is found for rates slower than one per second, where the percentage error is largest. A conceivable explanation of this exception is that it is spurious and due to readings of the voltmeter.

Our results on the influence of length of presentation, and the length of interval between presentation and reproduction are not entirely uniform. In general they fit in with the established facts

of the curve of forgetting, and that memory is more accurate when the material is presented for a longer time. An unexpected result was that an interpolated rate had no effect upon a reactor's accuracy in reproducing a rate. There were prominent individual differences in the extent and direction of effect which slow or fast initial rates had upon the reactor. The most constant effect was present in the case of the fastest rate which was reproduced. The reactors significantly underestimated to a greater extent this rate when the initial rate was slow.

Although the majority of subjects spontaneously made some response while they listened to a rhythm, we have not been able to show that these responses are responsible for more accurate memory for rhythm. Involuntary implicit responses may have occurred. Another possible explanation is that the directed responses were distracting, whereas they would have resulted in increased accuracy had they been practiced longer.

References

1. Arps, G. F., & Klemm, O. Der Verlauf der Aufmerksamkeit bei rhymischen Reizen. *Psychol. Stud.*, 1909, **4**, 505-529.
2. Blake, J. A. Reaction time measurement. Johns Hopkins Master's Essay. Baltimore, 1933.
3. Bolton, T. L. On the discrimination of groups of rapid clicks. *Amer. J. Psychol.*, 1892, **5**, 294-310.
4. ———. Rhythm. *Amer. J. Psychol.*, 1894, **6**, 145-238.
5. Brown, W. Temporal and accentual rhythm. *Psychol. Rev.*, 1911, **18**, 336-346.
6. Dresslar, F. B. Some influences which affect the rapidity of voluntary movements. *Amer. J. Psychol.*, 1892, **4**, 514-527.
7. Dunlap, K. A new rhythm and time device. *Science*, 1907, **26**, 257-258.
8. ———. Reactions to rhythmic stimuli, with attempt to synchronize. *Psychol. Rev.*, 1910, **17**, 399-416.
9. ———. Rhythm and the specious present. *J. Philos., Psychol., & Sci. Meth.*, 1911, **8**, 348-354.
10. ———. A study in rhythm perception. *Psychol. Bull.*, 1911, **8**, 68-69.
11. ———. Difference sensibility for rate of discrete impression. *Psychol. Rev.*, 1912, **19**, 32-59.
12. Hall, G. S., & Jastrow, J. Studies of rhythm. *Mind*, 1886, **2**, 55-62.
13. Heinlein, C. P. A new method of studying the rhythmic responses of children together with an evaluation of the method of simple observation. *J. Genet. Psychol.*, 1929, **36**, 205-228.

14. JASPER, H. H., & ANDREWS, H. L. Human brain rhythms: recording techniques and preliminary results. *J. Gen. Psychol.*, 1936, **14**, 98-126.
15. KOFFKA, K. Experimental-Untersuchungen zur Lehre vom Rhythmus. *Zsch. f. Psychol.*, 1909, **52**, 1-109.
16. LEATHERMAN, C. D. Limits of toleration in a complication problem. Johns Hopkins Dissertation. Baltimore, 1936.
17. MACDOUGALL, R. The structure of simple rhythm forms. *Psychol. Rev. Monog.*, 1903, **4**, 309-411.
18. MEUMANN, E. Beiträge zur Psychologie des Zeitsinns. *Philos. Stud.*, 1893, **8**, 431-509.
19. ————. Beiträge zur Psychologie des Zeitsinns. *Philos. Stud.*, 1894, **9**, 264-306.
20. ————. Untersuchungen zur Psychologie und Aesthetik des Rhythmus. *Philos. Stud.*, 1894, **10**, 249-322; 393-430.
21. MOEDER, W. D., & JENKINS, J. G. A condenser-charge timer. *Amer. J. Psychol.*, 1933, **45**, 742-744.
22. MILES, D. W. Preferred rates in rhythmic response. Johns Hopkins Dissertation. Baltimore, 1931.
23. MINER, J. B. Motor, visual and applied rhythms. *Psychol. Rev. Monog.*, 1903, **5**, 1-106.
24. RUCKMICK, C. A. A bibliography of rhythm. *Amer. J. Psychol.*, 1913, **24**, 508-519; 1915, **26**, 457-459; 1918, **29**, 214-218; 1924, **35**, 407-413.
25. ————. The rôle of kinesthesis in the perception of rhythm. *Amer. J. Psychol.*, 1913, **24**, 305-359.
26. SEASHORE, C. E. Motor ability, reaction-time, rhythm and time sense. *Univ. Iowa Stud. Psychol.*, 1899, **2**, 64-84.
27. ————. The sense of rhythm as a musical talent. *Music. Quar.*, 1918, **4**, 507-515.
28. ————. Manual of instructions and interpretations for measures of musical talent. Iowa City, Iowa.
29. ————. A new rhythm apparatus. *Science*, 1924, **59**, 146-147.
30. STETSON, R. H. A motor theory of rhythm and discrete succession. *Psychol. Rev.*, 1905, **12**, 250-270; 293-350.
31. ————. Rhythm and rhyme. *Psychol. Rev. Monog.*, 1903, **4**, 413-466.
32. SWINDLE, P. F. On the inheritance of rhythm. *Amer. J. Psychol.*, 1913, **24**, 180-203.
33. WALLIN, J. E. W. Investigations on rhythm, time, and tempo. *Psychol. Bull.*, 1906, **6**, 72-73.
34. ————. Experimental studies of rhythm and time. *Psychol. Rev.*, 1911, **18**, 100-131; 202-222.
35. WOODROW, H. A quantitative study of rhythm. *Arch. of Psychol.*, 1909, **14**, 1-66.
36. ————. The rôle of pitch in rhythm. *Psychol. Rev.*, 1911, **18**, 54-77.
37. ————. The reproduction of temporal intervals. *J. Exper. Psychol.*, 1930, **13**, 473-499.

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